# PATENT SPECIFICATION

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## (54) DRINKING WATER TREATMENT APPARATUS

(71) We, CULLIGAN INC. A corporation of the state of Delaware, United States of America, of Northbrook, Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a water conditioning apparatus.

The present invention provides a water conditioning apparatus which will continuously treat impure water and store the purified treated water for any intended use in the home or other location. The apparatus comprises a reservoir for the purified water, at least one housing mounted within the reservoir, a water purification module within the housing, an impure water inlet to the housing, a purified water outlet from the housing to empty into the reservoir, and a residual impure water outlet from the housing leading to a drain.

The water purification module is preferably preceded in the housing by a prefilter to initially filter out any suspended impurities, and an activated charcoal filter element is preferably positioned on or associated with the purified water outlet to remove any taste or odour in the purified water not removed in the previous treatment. The water purifier cartridge utilises an osmotic membrane with a reverse osmotic action to separate impure water into a purified stream and a residual of increased impurity contenr.

In a preferred embodiment of the present invention the impure water outlet provides a back pressure for the housing to assist in the reverse osmosis action. The back pressure is provided at the concentrated impure water outlet through the use of a filter screen and outlet connector assembly having a capillary tube which extends from the connector to and drains in a standpipe.

The water conditioning apparatus may have a primary reservoir storing the treated purified water and a second reservoir mounted within the primary reservoir for the cooling and storage of purified water to be dispensed from a separate faucet as cold water for drinking. The water in the primary reservoir is then used for cooking or other uses not requiring the water to be chilled. The second reservoir is formed of a thermal insulation material to reuce the heat transfer between the two reservoirs.

The water in the chilled water reservoir may be chilled by a thermoelectric cooler. The thermoelectric cooler includes a heat conductor extending into the reservoir and into the purified water therein. A thermoelectric module is mounted in the top of the reservoir sandwiched between a heat sink contacting the heat conductor and a heat exchanger which functions to draw heat away from the hot side of the module and thus cool the module. The heat exchanger employs the concentrated waste stream emanating from the water purified cartridge prior to draining into a standpipe.

An embodiment of the invention will now be described with reference to the accompanying drawings.

In the drawings:

Figure 1 is a front elevational view with a portion of the cover and reservoir broken away to show a water conditioner assembly according to the present invention with a single purifying housing or cartridge and a thermoelectric water cooler;

Figure 2 is an enlarged fragmentary vertical cross sectional view of the water conditioner assembly taken on the irregular line 2—2 of Figure 1 and showing the prefilter and charcoal filters of the purifier housing or cartridge and the lines for the purified water and concentrated impure water going to the reservoir and drain as normally occuring where the thermoelectric cooler is not present;

Figure 3 is a vertical cross sectional view of the apparatus taken on the line 3—3 of Figure 1 showing the normal connection of the

concentrated impure water line to the drain standpipe where the thermoelectric cooler is omitted;

Figure 4 is a top plan view of a heat exchanger utilized in the thermoelectric cooler as shown in Fig. 1;

Figure 5 is a vertical cross sectional view of the heat exchanger taken on the line 5—5 of Fig. 4 as well as showing the thermoelectric module and heat conducting members in the top wall of the chilled water reservoir;

Figure 6 is a schematic showing of the electrical circuit for the thermoelectric module.

Referring more particularly to the disclosure in the drawings wherein is shown an illustrative embodiment of the present invention, Fig. 1 discloses a water conditioning and purifying apparatus 10 having a primary purified water reservoir 11 closed by a cover 12. The reservoir 11 receives one or two water purifier units 13 (only one being shown), each having a two-part housing 14 which is joined at the center by flanges 15 retained together by suitable securing means such as the nuts and bolts 16; a sealing gasket (not shown) being provided between the flanges.

A source of raw impure water 17 to be treated and containing undesirable dissolved or undissolved solids passes through a suitable chemical feeder 18 supplying sufficient chemical to the water to control the pH thereof to an optimum level of approximately 5.0; because above and below this level the useful life of the membrane decreases. Thus, chemical treatment of the water, normally with an acidulent, modifies the pH thereof to a level which will yield an extended useful membrane life. The pretreatment feeder can also be used for feeding chemicals such as biological growth inhibitors or other chemicals which will alter the membrane environment to render it less destructive to the reverse osmosis membrane. The water passes through the conduit 19 from the feeder 18 to an inlet 21 connected to an inlet fitting 22 (Fig. 2) of the casing 14.

The casing 14 is formed of two substantially identical parts or sections 23,23, each having a generally cylindrical portion 24 with an axially offset passage 25 opening into the cylindrical portions 24 adjacent the flange 15 (Fig. 2). An axially offset inlet port 26 in the fitting 22 opens into a chamber 27 at the lower end of the lower cylindrical portion 24. Located within the chamber 27 of the casing is a cylindrical filter 28 having a central hollow passage or chamber 29; the filter being spaced from the interior wall of the chamber 27 to provide an annular chamber or space 31 therearound.

The filter 28 is positioned between a filter support 32 resting on a central projection 33 in the bottom of chamber 27 and an upper plate 34 having an O-ring seal and resting on a shoulder 35 formed in the casing 14. The upper plate 34 has a central recess 36 for one end of a module to be later described with a central depending projection 37 extending down to and received in a recess 38 in the support 32. The upper recess 36 includes one or more passages 39 communicating with the chamber 29 within the filter 28. The chamber 27 is further provided with arcuately spaced ribs 41 in the side wall thereof forming spaced passages communicating between the annular chamber 31 and the inlet port 26 around the filter support 32.

Within the elongated cylindrical portion 24 of the casing 14 is a reverse osmosis membrane module 42 having a lower seal 43 in the lower portion 23; which module includes a central module stem 44 extending from the module into the recess 36. The opposite end of the stem 44 extends through a central opening in an upper support plate 45 which is sealed in the upper portion 23 by O-ring 46. The support plate 45 is also positioned against a shoulder 47 in the upper portion 23 and a shoulder 48 on the stem 44 cooperates with a complementary shoulder in the plate 45.

The stem 44 extends into and terminates in an opening 49 in a lower membrane support 51 for a microporous membrane 52 utilized for the filtering of bacteria present in the water. An upper membrane support 53 has a central projection 54 containing a central passage 55 which is in communication (not shown) with a charcoal filtering medium 57 having a lower filter support 56. An upper filter support 58 abuts a central projection 59 on the end wall 61 of the upper portion 23. A plurality of passages 62 are located in the lower filter support 56, and the wall of the portion 23 is provided with ribs (indicated by the broken lines) 63 extending axially upwards from the shoulder 47, thus forming passages extending from an annular space 64 at the exterior of the charcoal filter 57 around the upper support 58, and to a space formed between the support 58 and the end wall 61, which space thus communicates via filter 57 with space 55. An axially offset outlet passage 65 communicates with the last mentioned space and with a fitting for the outlet conduit 66.

The reverse osmosis module 42 consists of a spirally wound semi-permeable membrane which permits the solvent phase of a solution to flow through it at a higher rate than the solute when an applied pressure differential is in excess of the osmotic pressure of the solution. The purified water or solvent in the module flows to and into the outlet tube or stem 44 leading to the opening 49 in the lower membrane support 51, through the microporous membrane 52 and the charcoal filter 57, around the upper filter support 58 and out the outlet passage 65 to the conduit 66. The impure water which is not purified becomes more concentrated in mineral content and passages longitudinally outward through the module 42 to the exterior thereof and enters the offset longitudinal passage 25 extending along

the exterior of the casing 14 through an opening 67 formed intermediate the ends of the joined cylindrical portions 24.

The lower end of passage 25 in lower portion 24 is plugged or capped by the cap 68, and the upper end of passage 25 in upper portion 24 is capped with a cap 69 forming an adapter for a capilliary drain tube 74. A generally conical screen 71 is positioned in the passage 25 by a resilient plug 72 thereabove having a central passage 73 to receive the end of the capillary tube 74. The capillary tubing may be formed of plastics material or stainless steel; however, if the water contains iron, a stainless steel tube is preferred as the water containing the iron tends to coat and clog a plastics material capillary tubing with precipitated iron.

Water enters the apparatus under a suitable pressure and at a preferred pH level. The control of the pH range has been found necessary, as previously stated, to reduce the cellulose acetate hydrolysis rate of the reverse osmosis membrane and hence to prolong the life of the membrane. As the reverse osmosis operation occurs only when the applied pressure is in excess of the osmosis pressure of the solution, the capillary tubing 74 provides a sufficient flow restriction so that the quantity of impure concentrate is regulated and also that the pressure exerted by the incoming impure water is preserved to promote the reverse osmosis action in the module.

As long as the module is operative and imperforate, no bacteria present in the impure water can pass through the membrane to be present in the purified water stream; however, the microporous membrane or filter 52 is positioned to stop any bacteria coming out of the reverse osmosis module 42; the bateria stopping the flow of water by plugging the filter 52. The purified bacteria-free water passes through the charcoal filter 57 to remove any remaining taste or odor from the water prior to filling the reservoir 11. The consumer obtains the purified water when required by means of the faucet or spigot 75. A drain standpipe 76 is provided at the rear of the reservoir 11 into which the drain capillary tubing 74 extends.

As more clearly seen in Fig. 3, the drain standpipe 76 is formed in a central vertically arranged recess 77 in the rear wall of the reservoir 11, the recess having a top wall or weir 78 with an opening 79 providing an overflow connection for the reservoir leading to the standpipe. The capillary tubing 74 would normally extend through an opening in the top wall 81 closing the reservoir 11 into the standpipe. A drain fitting 82 receiving flow from the standpipe 76 terminating thereabove leads to a drain pipe 83 from the apparatus 10. Also, the purified water conduit 66 normally extends downward through the wall 81 into the reservoir 11 to terminate adjacent the bottom thereof (see Fig. 2).

As seen in Fig. 1, an additional reservoir 84 can be removably secured within the main reservoir 11 in the position which normally is utilised for a second reverse osmosis cartridge unit 13. This reservoir 84 is preferably formed of a thermal insulating material such as "Styrofoam' or (Trade Mark) or polyurethane foam and is cemented to a cover 85 therefor. The reservoir 84 and cover 85 can be bolted to the top wall 81 for the reservoir or cemented thereto. The reservoir 84 includes an opening 86 receiving the end of the purified water conduit 66 and also forming an overflow opening for the reservoir, so that the cold water reservoir 84 is initially filled and then the overflow fills the main reservoir 11.

A cold water outlet conduit 87 extends from a suitable fitting 88 in the bottom of the reservoir 84 to a second faucet or spigot 89 mounted either in the front wall of the reservoir 11 as shown or mounted in the plugged fitting 91 of the reservoir 11 as shown or mounted in the plugged fitting 91 in the bottom of the reservoir (see Figs. 1 and 2); the faucet 89 preferably utilizing a lift plate 92 to actuate the valve therein. The opening 86 is located in the upper rear section of the reservoir 84 and the fitting 88 is located at the lower front portion of the reservoir 11 to permit mount of the unit 10 in either the horizontal or vertical position. When in a horizontal position, the cold water faucet 89 would be mounted in the position of the ambient temperature water spigot 75 and vice-versa.

Within the reservoir 84 (Fig. 1 and 5), a generally U-shaped heat conductor 93 is mounted at its connecting portion 94 to a heat sink 95 embedded in the foam plastics forming the cover 85. The heat conductor 93 is formed of a high heat conducting material, such as copper or aluminium, and the legs extend downwardly to adjacent the bottom of the reservoir 84. The heat sink 95 is also formed of a high heat conductive material, such as copper, and abuts one side of a plurality of thermoelectric modules 96 connected in series and having a hot side 98 and a cold side 97 abutting the heat sink 95. The hot side 98 abuts the heat conductive housing 101 of the heat exchanger 99.

As is well known in the art, a thermoelectric module as used herein comprises a junction of dissimilar thermoelectric elements commonly known as "N" and "P" materials. A current flowing from an "N" material to a "P" material causes heat to be absorbed at the junction of the elements; while conversely current flowing in the opposite direction from a "P" material to an "N" material causes heat to be dissipated at the junction.

The heat exchanger 99 has a cover 102 suitably sealed onto the housing 101 by a ring sealing means or gasket 103 and has a tangen-

tial inlet 104 (Fig. 4) connected to and receiving the drain capillary tubing 74 from the reverse osmosis module 42 and a tangential outlet 105 on the opposite side (Figs. 4 and 5) with tubing 106 leading from the outlet to the drain standpipe 76 (Fig. 1). Mounted directly above the heat exchanger 99 on the reservoir 11 as close as possible to the heat exchanger is a power supply 107 which is shown schematically in Fig. 6.

A plug 108 connects to a source of A. C. power ith the leads 109, 111 extending into the power supply 107 for the thermoelectric module. Lead 109 is connected to the primary winding of transformer 112 with a lead line 113 from the primary winding of the transformer to a low temperature cut-off switch 114. In series with switch 114, which is located adjacent the heat sink 95, is a high temperature cut-off switch 115 located adjacent the heat exchanger 99 and connected to the other lead 111 from the plug 108. Both the high temperature and low temperature cut-off switches 115 and 114, respectively, are utilized to disconnect the power to the transformer 112 in the event of either excessive temperature occurring at the heat exchanger for reasons such as failure of concentrate water flow or before an icing condition is encountered at the heat sink.

The center tapped secondary winding of the transformer 112 is connected through a lead 116 to a filter choke 117 which is, in turn, connected by lead 118 to the thermoelectric modules 96. The modules 96 are connected by leads 119 to rectifier diodes 121, with leads 122 from the diodes 121 to the secondary winding of the transformer 112. This arrangement provides DC power for the thermoelectric modules. As the transformer 112, choke 117 and diodes 121 are closely adjacent the top of the heat exchanger 99, they are also cooled thereby.

In operation, the concentrate water from the drain tubing 74 flows through the heat exchanger 99 to draw heat from and cool the hot side 98 of the thermoelectric modules 96. As current is flowing through the modules, the temperature differential is maintained causing a decrease in the temperature of the cold side 97 of the modules which results in a drawing or extracting of the heat from the water in the reservoir 84 through the heat conductor 93 and heat sink 95. The entire reservoir 84 and cover 85 can be bounded on both sides by a medically safe rigid material 123 to retain the purity of the water therein and in the main reservoir 11.

Both the ambient water spigot 75 and the cold water faucet 89 are of commercially available design; the faucet 89 having the lift plate 92 actuating a valve within the faucet to dispense cold water.

WHAT I CLAIM IS:—

1. A water conditioning apparatus to provide purified water, comprising a reservoir for the purified water, at least one housing mounted within the reservoir, a water purification module within the housing, an impure water inlet to the housing a purified water outlet from the housing to empty into the reservoir, and a residual impure water outlet from the housing leading to a drain.

2. A water conditioning apparatus as set forth in claim 1, including a capillary tube extending between the residual impure water outlet and the drain, a resilient plug receiving one end of the capillary tube and being positioned in the impure water outlet, and a filter screen in the outlet.

3. A water conditioning apparatus as set forth in claim 1 or 2, including a filter in the housing upstream of the module to filter the incoming impure water, and a charcoal filter in the housing downstream of the module and communicating with the purified water outlet and filtering the purified water from the module.

4. A water conditioning apparatus as set forth in claim 1, 2 or 3 including a spigot communicating with the reservoir adjacent the bottom thereof.

5. A water conditioning apparatus as set forth in claim 2, or in claim 2 together with claim 3 or 4 including a drain standpipe in a recess at the exterior of the reservoir and an overflow opening in the reservoir communicating with the standpipe, the capillary tube communicating with and emptying into the standpipe.

6. A water conditioning apparatus as set forth in any one of claims 1 to 5, including a chemical feeder communicating with the impure water inlet upstream of the housing for feeding chemicals into the impure water.

7. A water conditioning apparatus as set forth in any one of claims 1 to 6, including a cold water reservoir removably mounted within the first mentioned reservoir, the cold water reservoir having an inlet and overflow opening therein, the purified water outlet of the housing communicating with the opening for filling the cold water reservoir, an outlet from the cold water reservoir communicating with a spigot for dispensing cold water. and means to cool the water in the cold water reservoir.

8. A water conditioning apparatus as set forth in claim 7, in which the means to cool the water in the cold water reservoir includes a heat conductor extending into the water in the cold water reservoir, a plurality of thermoelectric modules drawing the heat from the heat conductor and a heat exchanger drawing the heat from the hot side of the modules.

9. A water conditioning apparatus as set forth in claim 2 together with claim 8, in which the capillary tubing from the impure water drain outlet is connected to the inlet of the heat exchanger and a tube extends from the

outlet of the heat exchanger and empties into the drain.

10. A water conditioning apparatus as set forth in claim 8 or 9, including a power supply for the thermoelectric modules comprising a power source, a transformer having a primary winding, a high temperature cut-off switch and a low temperature cut-off switch connected in series with the primary winding, a secondary winding on the transformer, a choke and diodes the secondary winding, choke and diodes being connected in series with the thermoelectric modules.

11. A water conditioning apparatus as set forth in claim 10, in which a heat sink is positioned between the heat conductor and the thermoelectric modules, the low temperature cutoff switch being positioned adjacent to the heat sink and the high temperature cut-off switch being positioned adjacent to the heat exchanger.

12. A water conditioning apparatus as set forth in any one of claims 1 to 11 including a microporous membrane positioned in the housing downstream of the water purification module to filter out any bacteria present in the water.

13. A water conditioning apparatus as set forth in any one of claims 1 to 12, in which the housing includes a pair of casing halves joined together, each half having a cylindrical portion and an axially offset longitudinally extending drain passage communicating with the cylindrical portion intermediate the ends of the casing.

14. Water conditioning apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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1202215 COMPLETE SPECIFICATION

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Sheet 1

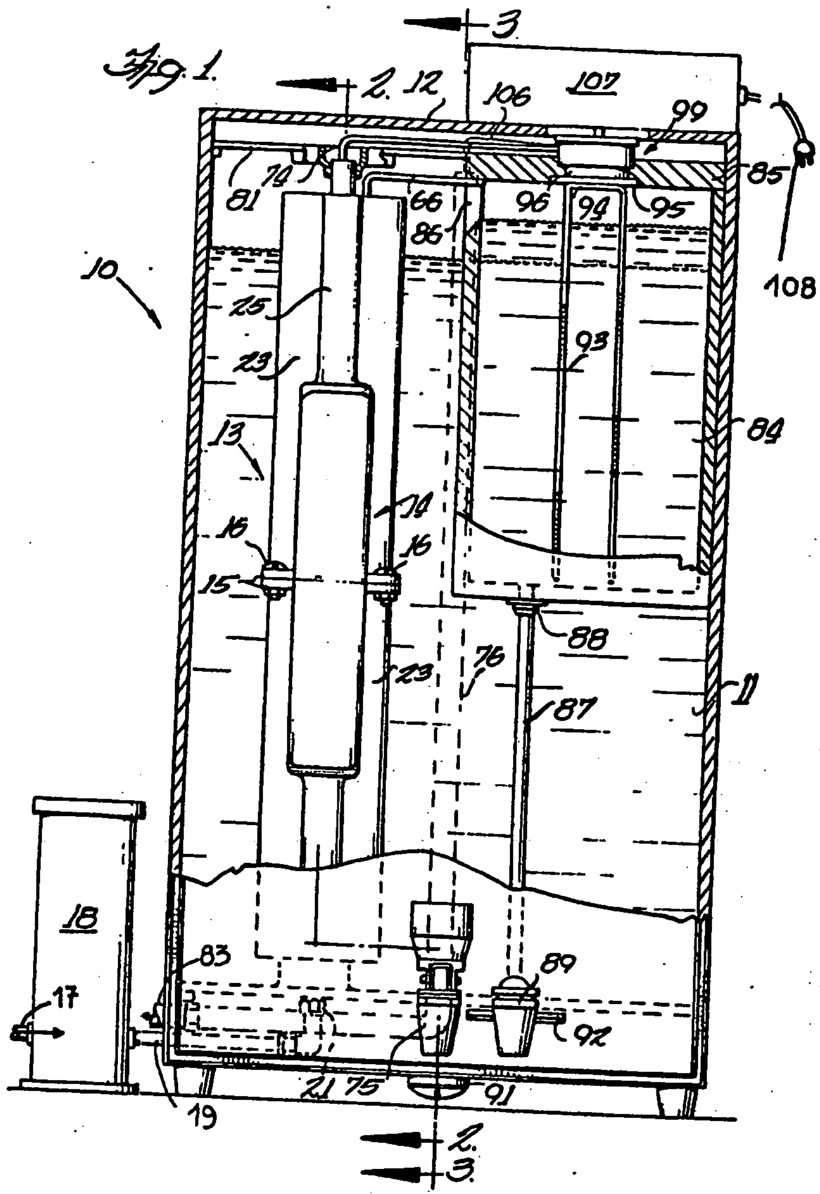

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Fig 2.

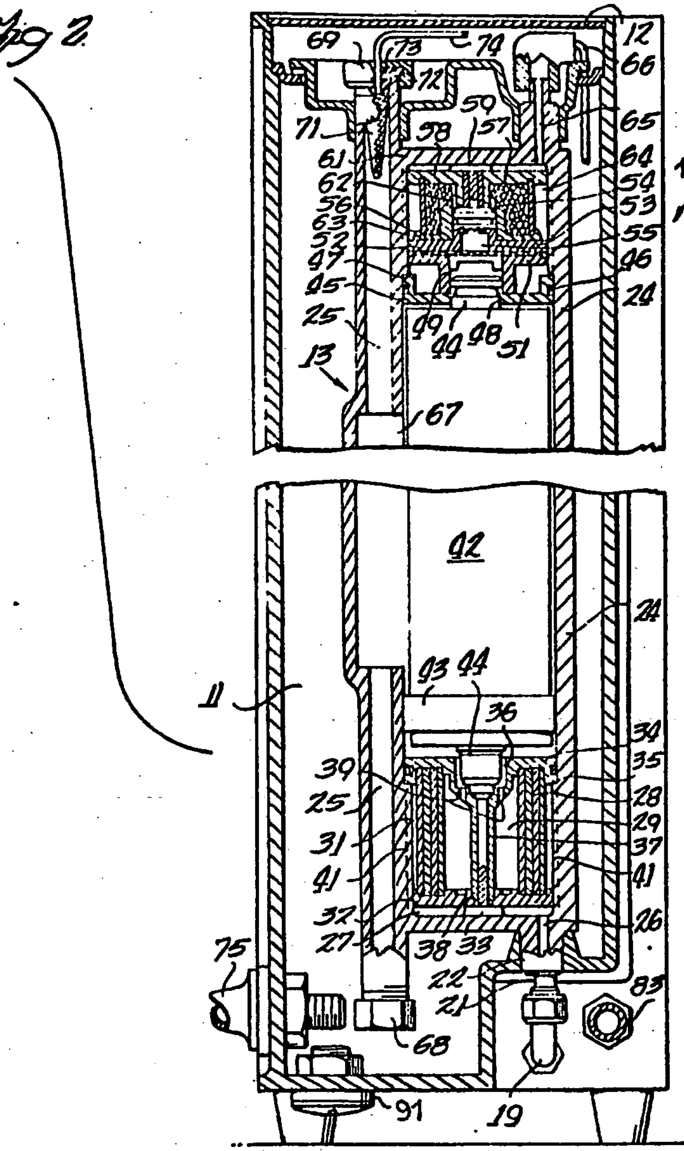

Fig 3

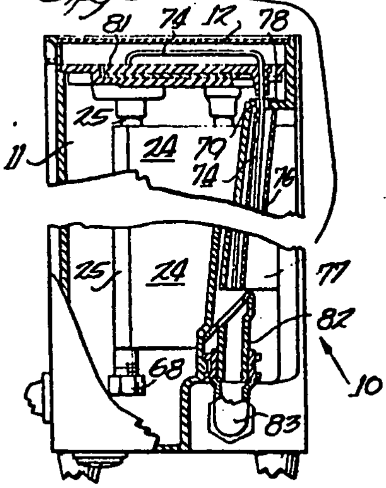
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Fig 4

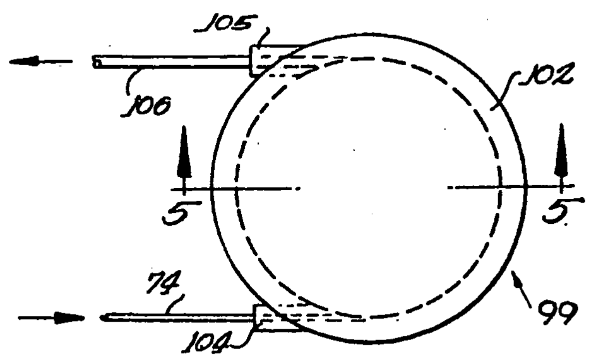
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Fig 5

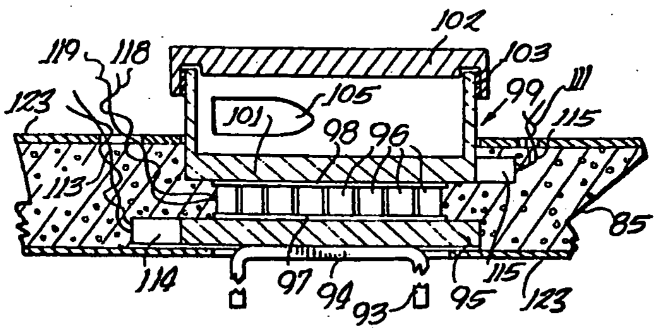
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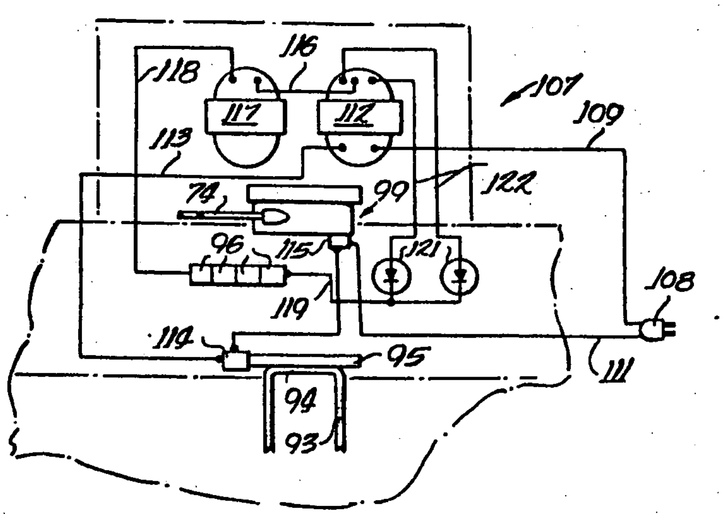
Fig 6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